

For Reference

NOT TO BE TAKEN FROM THIS ROOM

Thesis
1969(F)
179

For Reference

NOT TO BE TAKEN FROM THIS ROOM

Ex libris
UNIVERSITATIS
ALBERTAENSIS



THE UNIVERSITY OF ALBERTA
DEVELOPMENTAL CHANGES IN ATTRIBUTE PREFERENCE
AND
ATTRIBUTE USAGE IN A LEARNING TASK

by



CAROLYN PATRICIA NUTTER

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF ARTS

DEPARTMENT OF PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1969

UNIVERSITY OF ALBERTA
FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Developmental Changes in Attribute Preference and Attribute Usage in a Learning Task" submitted by Carolyn Patricia Nutter in partial fulfilment of the requirements for the degree of Master of Arts.

Abstract

Two experiments were conducted to study the developmental course of the relationship between children's attribute preferences and their ability to use preferred and non-preferred attributes in a learning situation. Children from Kindergarten, Grade 1, Grade 2 and Grade 3 served as subjects. Experiment 1 investigated attribute preference under non-reinforcement conditions. Children in Kindergarten and Grade 1 preferred form or color while those in Grade 2 and Grade 3 preferred function. Experiment 2 investigated children's ability to use preferred or non-preferred attributes when they were reinforced for doing so. The Kindergarten subjects showed no evidence of being able to use non-preferred attributes and performed relatively poorly even when the preferred attribute was relevant. Subjects from Grade 1 used non-preferred attributes better than preferred attributes in this task. Subjects from Grade 2 and Grade 3 used all attributes adequately. The results were discussed in terms of the consistency and flexibility of attribute usage among the children.

ACKNOWLEDGEMENT

My thanks to Dr. Barbara Schaeffer for allowing me freedom while giving me guidance.

Table of Contents

	Page
Introduction	1
Method	9
Experiment 1	9
Subjects	9
Stimulus materials	9
Apparatus	9
Procedure	11
Experiment 2	14
Subjects	14
Apparatus	14
Design	14
Procedure	15
Results	18
Experiment 1	18
Experiment 2	20
Discussion	31
References	40
Appendices	42
A. List of Stimulus Sets	43
B. Probe Questions	44
C. Orders of Presentation	45

List of Tables

Table	Page
1. Percent Judgments based on Different Attributes (based on Bruner <u>et al</u> , 1966)	3
2. Total Number of Function, Form, and Color Choices for Each Grade Level.....	18
3. Number Subjects at Each Grade Level Preferring Function, Form, or Color, and Number of Choices based on Preferred Attribute	19
4. Summary of the Analysis of Variance of the Learning Data	22
5. Orthogonal Components of the Attribute Main Effect and Interaction with Grade	23
6. Linear Components of the Interactions with Trials	23
7. Orthogonal Components of the Interactions of Attri- bute and the Linear Component of Trials	24
8. Mean Proportion of Total Errors of Each Type	29
9. Number of Subjects at Each Grade Level Verbalizing 0, 1, 2, or 3 Criterial Attributes	30

List of Figures

Figure	Page
1. A sample stimulus set	10
2. The apparatus	12
3. Graphs of the means for each attribute group and each grade level	21
4. Graph of the G x T interaction	26
5. Graph of the A x T interaction	26
6. Graph of the G x A ₁ X T ₁ interaction	27



Introduction

Developmental studies of judgments of equivalence have been concerned with two aspects of such judgments, the attribute (or attributes) on the basis of which equivalence judgments are made, and the cognitive structures which underly the judgments. Although changes in both these aspects follow a parallel course of development (Olver, 1961), the present study is primarily concerned with developmental changes in attribute preference.

Bruner, Goodnow, and Austin (1956) have drawn a distinction between defining and criterial attributes. An attribute is defined as any feature of an object or event that may assume discriminably different values from event to event. Criterial attributes are those which a subject uses in making categorizations (i.e., equivalence judgments). The defining attributes of a concept are set down by some authority external to the subject. In most experimental concept learning situations, defining attributes are determined arbitrarily by the experimenter. A subject is said to have attained a concept when his criterial attributes have been brought in line with the defining attributes, that is, lead to the same judgments as the defining attributes.

In an experimental situation, a subject can be expected to show an initial tendency to use some criterial attributes in preference to others. One of the factors which appears to determine the subject's preference is his developmental level. The present study will address itself to the question of how developmental

changes in criterial attribute preference are related to performance in a learning situation requiring the utilization of various defining attributes.

Attribute preference is reflected in a tendency for a subject (or group of subjects) to use one attribute more than others in making equivalence judgments when no particular consequences are attached to the judgments. Investigations of attribute preference have inferred attribute utilization from two types of behavioral data: (a) from verbal responses given by the subject, regardless of the stimuli which are grouped together, or (b) from the nature of the stimuli which the subject selects as being equivalent. In the latter case, the attribute which the experimenter had in mind when constructing the stimulus sets is assumed to be the attribute which the subject uses.

Bruner, Olver, and Greenfield (1966) have investigated equivalence judgments in American school children using both verbal and pictorial stimuli. With verbal stimuli, the experimenter formed progressively larger stimulus groups and asked the child to say how the members of each group were alike. With pictorial materials, the child was presented with an array of drawings of common objects, instructed to select some that were alike, and then to say how they were alike. In both cases, the subject's verbal responses were taken as indicating the type of criterial attribute used. For example, reasons such as "They are all round," or "They are all yellow," indicated the use of perceptible attributes, whereas

"They are all to eat," or "They are all food," indicated that functional or nominal equivalence was the basis of grouping.¹ With both procedures, older subjects gave a higher proportion of reasons based on functional equivalence and a lower proportion based on perceptible attributes than did younger subjects (see Table 1). Perceptible attributes were used to a lesser extent in the verbal than in the pictorial task, probably because verbal stimuli do not provide immediate access to the perceptible qualities of objects, and because the experimenter presented verbal stimulus groups whose members could not be easily assigned a common value of any perceptible attribute.

Table 1

Percent Judgments based on Different Attributes

(based on Bruner et al, 1966)

	Pictorial Stimuli		Verbal Stimuli	
	Attribute Used		Attribute Used	
Grade	Perceptible	Functional*	Perceptible	Functional*
1	47%	36%	28.6%	58.6%
3	27%	71%		
4			13.6%	85.8%
6	20%	79%		

*This column includes reasons based on nominal equivalence.

¹Nominal groupings, i.e. groupings of objects which have a common label, are usually implicitly functional (Bruner et al, 1966, p. 276). Therefore, we will count them as such in the present paper though Bruner et al (1966) classified them separately.

Bruner et al (1966) report a similar developmental sequence, with a slight delay in the ages at which the transitions occur, in urban school children in Mexico City, in West Africa, and among Eskimo children in Anchorage, Alaska. However, a considerable delay in the decrease in reliance on perceptible attributes is evident in rural Mexican and West African children. In fact, adult West Africans who were both rural and unschooled still relied solely on perceptible attributes.

Several investigators have provided evidence that, within the perceptible domain, there is a decrease in reliance on color and an increase in reliance on form as a criterial attribute (Brian & Goodenough, 1929; Colby & Robertson, 1942; Kagan & Lemkin, 1961; Corah, 1964; Suchman & Trabasso, 1966a). All these investigators presented subjects with sets of geometrical stimuli containing a standard and from two to eight comparison stimuli, constructed so that color and form were equally available as criterial attributes. Subjects were instructed to indicate the comparison stimulus which was "the same as," or "like," or "belonged with" the standard. The attribute used by the subject was inferred from the comparison stimulus which he chose.

Brian and Goodenough (1929) reported an increase in the number of form choices and a decrease in color choices in the three to six year age range. Colby and Robertson (1942) categorized individual subjects as displaying color or form preference, a mixed preference if 60% to 90% of their responses were of one type,

and a pure preference if 90% or more were of one type. They found an increase with age in the percentage of subjects exhibiting a pure form preference, from 26% of the youngest group (3:5 - 6:1 years) to 76% of the oldest group (7 - 9:1 years). Only in their youngest subgroup (3:5 - 4:5 years) was color preference relatively more frequent. Kagan and Lemkin (1961) are the only investigators to report sex differences. They found an increase with age in the number of form choices and a corresponding decrease in color choices only in girls. Even their younger subjects (Median age = 3:9 years), however, gave slightly more form than color responses. Corah (1964) reported that his younger group (Median age = 4:9 years) made more choices based on color than did his older group (Median age = 8:9 years). Suchman and Trabasso (1966a) found that, at the youngest ages studied (2:10 - 3:5 years, and 3:6 - 3:11 years), color choices outnumbered form slightly (58% to 42%). In the oldest group, 74% of the choices were form choices.

In summary, children, beginning at the age of three or four years, tend increasingly to use form in preference to color as a criterial attribute in making equivalence judgments. Later, function, as opposed to perceptible attributes in general, becomes the preferred attribute.

The studies thus far reviewed have been concerned with the attributes which children use when no constraints are placed on their responding. If a contingency were introduced such that subjects were reinforced only for equivalence judgments based on

a specified attribute, we would expect an interaction between age and relevant attribute. Younger subjects would be expected to perform relatively better if judgments based on color or form were required. Older subjects should perform relatively better when judgments based on functional equivalence are appropriate. Such a procedure would provide data concerning the extent to which subjects at various ages can use non-preferred attributes when it pays to do so.

Lee (1965) used an oddity task to study how effectively young children could make equivalence judgments based on various attributes, including form and color. He instructed subjects to pick out one of three stimulus objects which was different from the other two, and reinforced them for correct responses. Within each set of stimuli, two attributes were varied. With respect to the relevant attribute, two of the stimuli were the same and one was different. Each of the three objects was different with respect to the irrelevant attribute. The relevant attribute varied from trial to trial. Under these conditions, the two younger groups of children (Mean ages = 3:10 and 4:10 years) made more errors on the sets in which form was relevant than on those in which color was relevant. The oldest group (Mean age = 5:9 years) made more errors when color was relevant. Thus, the developmental change in attribute preference from color to form is paralleled by a change in the relative difficulty of making judgments based on these attributes. The number of color errors actually increased signifi-

cantly with age, perhaps indicating that the development of a preference for using form interfered with the use of color as a criterial attribute. However, the average number of errors was small for all groups (maximum of three errors out of ten trials), indicating that the subjects could use both attributes fairly well.

Suchman and Trabasso (1966b) have demonstrated an interaction of attribute preference with attribute relevance. Four- and five-year-old children were tested for color or form preference (Suchman & Trabasso, 1966a), then trained with either their preferred or non-preferred attribute relevant and the other attribute irrelevant. Training consisted of sorting cards into two sets in accord with sample cards. The cards to be sorted varied in color and form such that, if form was relevant, a sort entirely on the basis of color would lead to an error rate of 50% and vice versa. Thus, if the non-preferred attribute was relevant, the subject had to overcome his preference in order to perform adequately. Subjects who had shown a color preference made significantly more errors when form was relevant than when color was relevant. Form-preferring subjects made significantly more errors when color was relevant. In a second experiment, the children were trained with form and color redundant and then tested with one relevant and the other irrelevant. With either attribute relevant, subjects who preferred the relevant attribute made significantly fewer errors than subjects who preferred the irrelevant attribute. The authors conclude that "stimulus preferences . . . influence the order of attainment for dimensional concepts." (Suchman & Trabasso, 1966b, p. 188)

Finally, data on adult concept attainment indicate that attributes preferred by younger children are more difficult for adults to use than those which are preferred by older children. Heidbreder (1946a,b) and Heidbreder, Bensley, and Ivy (1948) presented subjects with a series of lists in which pictorial stimuli were paired with nonsense-word labels. Each list contained instances of the same concepts. For example, each list might contain a different picture of a bird, and in each list it would be paired with the same label. Concept attainment was said to have occurred when a subject consistently gave the appropriate label to the first occurrence of new instances of the concept. Concepts of concrete objects (comparable to Bruner et al's, 1966, nominal groupings) were attained more quickly than form concepts (Heidbreder, 1946b). Form concepts were attained in fewer trials than color concepts (Heidbreder et al, 1948). These results suggest that, as attribute preference changes, new preferences interfere with the learning of concepts based on attributes preferred earlier.

The purpose of the present study was twofold. Experiment 1 was an attempt to replicate the findings concerning developmental changes in attribute preference using modified materials and a different procedure. Experiment 2 was designed to investigate the extent to which such preference changes were paralleled by changes in performance on a learning task requiring the utilization of the attributes of color, form, or function.

Method

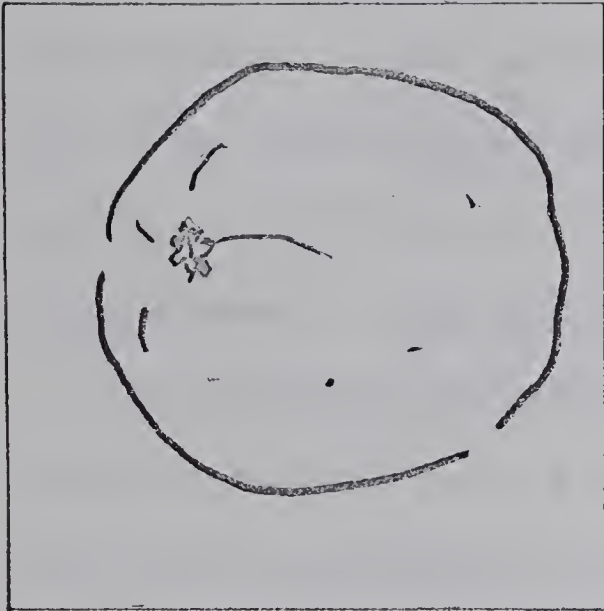
Experiment 1

Subjects. Thirty-two students from the Talmud Torah school in Edmonton, Alberta, Canada, eight each from Kindergarten, Grade 1, Grade 2, and Grade 3 (K, G1, G2, and G3), served as subjects (Ss). Their average ages were 5:2, 6:4, 7:6, and 8:3 years, respectively. There were 4 male and 4 female Ss in K and G1, 3 males and 5 females in G2, and 5 males and 3 females in G3.

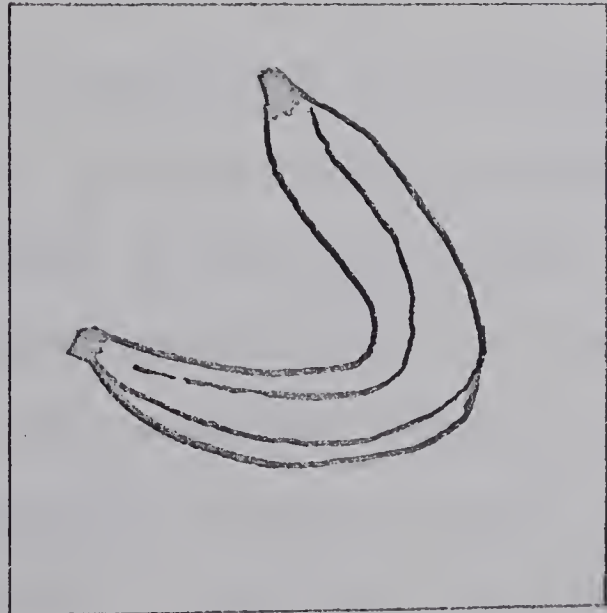
Stimulus Materials. Watercolor drawings of common objects served as stimuli. Each drawing was on a 2 1/4 in. square card which was pasted on a block of wood 2 7/8 in. square by 1/4 in. thick. The blocks were treated with a clear plastic spray to prevent smudging.

Twenty-one sets of four stimuli each were constructed. Each set consisted of a standard and three comparison stimuli, one the same predominant color, one the same general shape, and one serving the same function as the standard. A sample stimulus set is depicted in Figure 1. A list of the other sets used is presented in Appendix A.

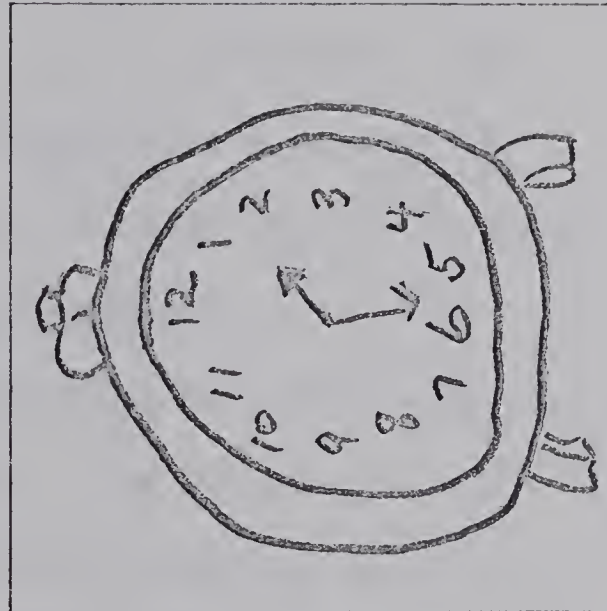
Apparatus. Stimuli were presented by means of the apparatus diagrammed in Figure 2. The base of the apparatus was 24 in. wide and 15 in. deep. Beginning 6 in. from the front of the apparatus, a panel, 15 in. high, extended up and back at an angle of 60° to the base. A slot (A in Figure 2), 4 in. square, was



Standard



Function



Form



Color(orange)

Figure 1. A sample stimulus set.

hinged 7 in. from the base of the apparatus so that it could be swung back through the apparatus and the standard stimulus slipped into it. The tray (B in Figure 2) was 13 in. wide and had three slots, one for each of the comparison stimuli. When placed in the tray, the comparison stimuli were separated by 1 1/2 in. The tray could be pulled to the back of the apparatus for insertion of the stimuli. A hinged panel (C in Figure 2), 2 in. deep, obstructed the S's view of the tray when it was at the back of the apparatus. Three circular wells, 2 in. in diameter, were cut in the tray such that they were hidden from view when the stimuli were in position. The purpose of these will be described in Experiment 2. The apparatus was painted gray.

The apparatus was placed on a child-sized table and the S seated in front of it on a small chair. The experimenter (E) sat behind the apparatus and could view S's behavior over the top. A microphone was placed to S's left to record portions of the experimental session.

Procedure. S was brought into the experimental room and asked to sit down in front of the apparatus. E took her position behind the apparatus and asked S's name and age. E then told S she had some pictures and she wanted S to answer some questions about them. The first stimulus set was displayed and S was asked: "Which one of these (E pointed to each of the comparison stimuli) is most like this one (E pointed to the standard)?" When S had indicated his choice, either verbally or by pointing, E manually recorded the

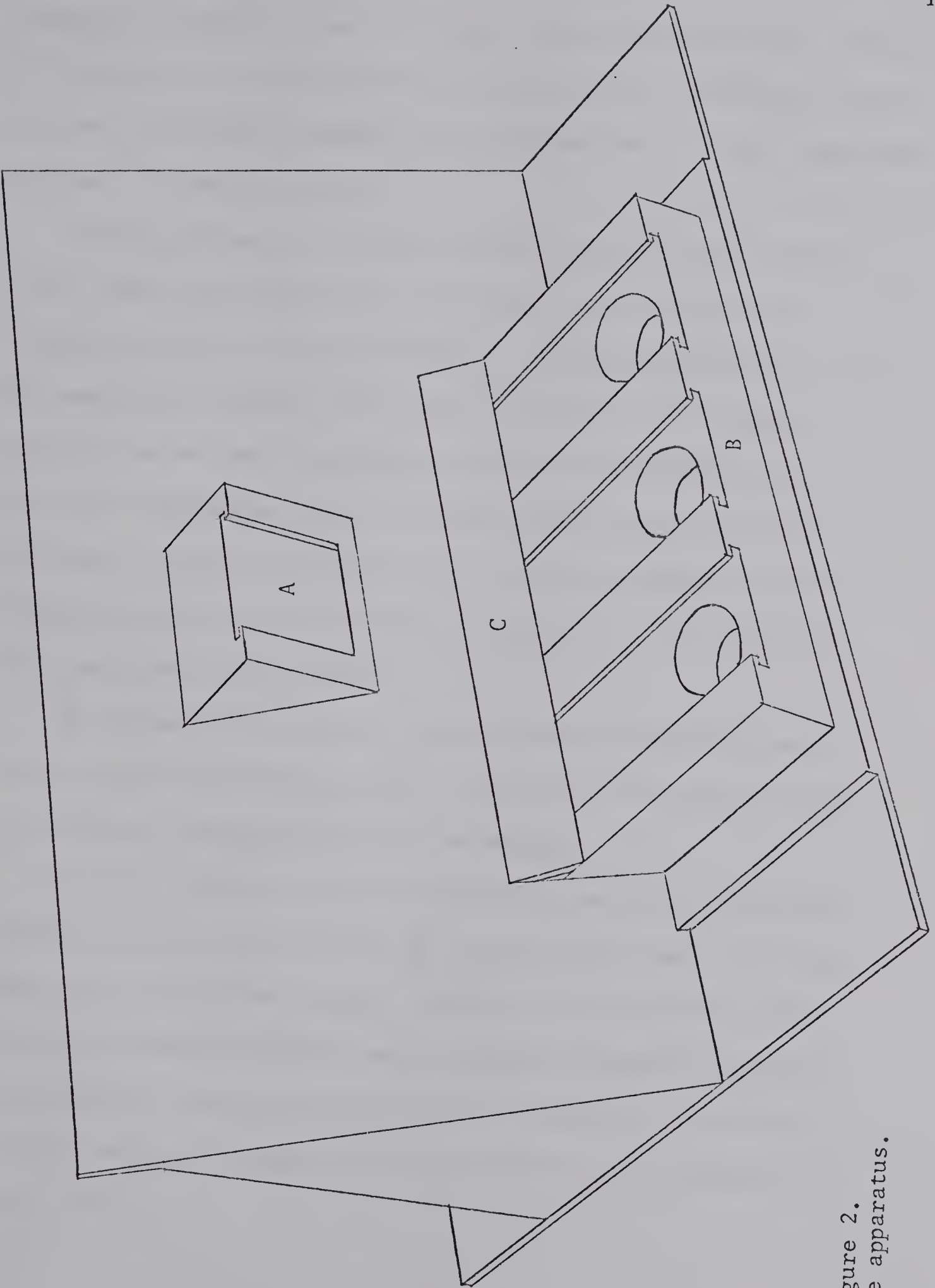


Figure 2.
The apparatus.

response as function, form, or color. The stimuli were then withdrawn and the next set presented. The interval between successive presentations (trials) was variable, but averaged about 17 sec. Twenty-one sets were presented in all.

After S had made his choice on the final set he was asked "Why?" When S had responded, E pointed to each of the other comparison stimuli in turn and asked: "Is this (E pointed to the comparison stimulus) like that (E pointed to the standard stimulus) in any way?" If S did not answer or responded "No" for either comparison stimulus, further questions were asked in an attempt to elicit an appropriate response. Examples of the follow-up questions are presented in Appendix B. The questions and answers were tape-recorded.

At the end of the session S was offered some small plastic toys as a gift for "helping out." Then S was dismissed and asked not to discuss the game with his classmates.

The first twenty stimulus sets were presented in a different random order for each of the Ss at a given grade level. The same orders were used across grades. Within each set in each order, the three comparison stimuli were randomly assigned to position. The orders of presentation are listed in Appendix C. The final stimulus set was the same for all Ss to facilitate comparison of their answers.

Experiment 2

Subjects. Ninety-six students from the Talmud Torah school at Edmonton, Alberta, Canada, 24 each from K, G1, G2, and G3, served as Ss. Their mean ages were 5:4, 6:4, 7:5, and 8:4 years, respectively. There were 12 male and 12 female Ss in all but G2, where there were 11 males and 13 females.

Apparatus. The stimulus materials and apparatus of Experiment 1 were used in Experiment 2. In addition, three solidly-colored wooden blocks, 2 1/4 in. square by 1/4 in. thick, one yellow, one red, and one blue, served as pretraining stimuli. Small plastic toys were used as reinforcers. A plastic glass in which to put the toys was placed to the right of S.

Design. The design was a 4 x 3 x 4 factorial, with two factors assigned between Ss and one within Ss. The four grade levels, K, G1, G2, and G3, formed one factor. Relevant attribute, designated Fu, Fo, and C, was the other between Ss factor. The Fu groups were reinforced for choices of the comparison stimuli which were functionally equivalent to the standard, the Fo groups for choices based on form equivalence, and the C groups for choices based on color equivalence. Thus there were 12 groups in all with eight Ss in each group.

Four blocks of trials formed the within Ss factor. Each S was given 20 trials. The trials were divided into blocks of five trials each for purposes of analysis.

Procedure. Ss from a given grade level were assigned to Experiment 1 or to one of the groups of Experiment 2 in rotation, with the exception that the order of running groups was sometimes varied in an attempt to equalize the number of males and females in each group. Equal sex distribution was attained except in the G2, Fo group in which there were three males and five females. Ss from G3 were run first followed by Ss from G1, K, and G2 in that order.

S was brought into the experimental room and asked to sit down in front of the apparatus. He was asked for his name and age. E then came from behind the apparatus and stood beside S and demonstrated the procedure while giving verbal instructions as follows:

Verbalization

Let me show you what we'll be doing. I'll be taking little toys like this

and hiding them in one of these holes

and covering up the holes with blocks of wood.

Now, your job is to find where the toy is hidden. When you think you know, you slide back the block of wood that you think the toy is under.

Demonstration

E showed S one of the small plastic toys.

The toy was placed in each hole in turn and removed. Then it was placed in the center hole and left there.

E placed the three solidly-colored blocks of wood over the holes.

E slid back the center block revealing the toy.

Now, if you find the toy on the first try, you put it in this cup over here.

E removed the toy from the hole and dropped it into the plastic glass.

But if you make a mistake and have to try again, I take the toy back and hide it again.

E took the toy from the glass and kept it.

The statement: "You get as many toys in the cup as you can," was added beginning with the G1 Ss in an attempt to insure that the younger children understood the object of the game.

Thus, the procedure was a correction procedure, but S was reinforced (i.e., allowed to put the toy in the cup beside him) only if his first response was correct.

Following the instructions, E returned to her seat behind the apparatus. Two practice trials were given using the solidly-colored blocks of wood. No standard stimulus was presented on these trials. Where necessary, instructions were repeated. An attempt was made to have one response reinforced and one not reinforced on practice. However, due to the nature of the apparatus and procedure, this was not always possible. Three Ss in G3, four in G2, and two in K were reinforced for both practice trials. No systematic position or stimulus contingencies were imposed during practice.

After the practice trials, E announced that we would now try the "real game." As the first set of four stimuli was presented, E said: "Now this time I'll give you a hint. The toy is hidden under one of these (E pointed to the comparison stimuli) that is like this (E pointed to the standard) in some way."

The first 20 stimulus sets were presented in one of the eight random orders used in Experiment 1. A different order was used for each S in a group and the same orders were used across groups. If S appeared not to be attending to the standard, an attempt was made to redirect his attention to it by repeating the hint. This was necessary for the young children more often than for the older children. The inter-trial interval was variable but averaged about 20 sec.

The final stimulus set was the same for all Ss in Experiments 1 and 2. Before it was presented, S was told that no toy would be hidden but that he would be asked some questions about the pictures. The set was presented and S was asked: "Which one of these is most like this one?" Concurrently, E pointed to each of the appropriate stimuli. S's response was followed by the probe questions used in Experiment 1. The questions and answers were tape-recorded.

Results

Experiment 1

The number of Fu, Fo, and C choices was summed over the first 20 trials for each subject and over subjects at each grade level. The results are presented in Table 2. A chi square analysis was significant ($\chi^2 = 219.15$, df = 6, p < .01).

Table 2

Total Number of Function, Form, and Color Choices
for Each Grade Level

Grade	Attribute		
	Fu	Fo	C
K	23	83	54
G1	50	81	29
G2	115	41	4
G3	125	32	3

Each subject was also classified as preferring Fu, Fo, or C on the basis of the majority of his choices. For example, if 11 or more of the first 20 choices made by a subject were Fu choices, he was classified as preferring Fu. It was possible to classify every subject on this basis. The results are presented in Table 3. A chi square analysis was significant ($\chi^2 = 18.66$, df = 6, p < .01).

The means and standard deviations in Table 3 are based on the number of choices by each subject which were based on the preferred

attribute of that subject. The linear component of the trend over grades is significant, indicating a significant increase with grade level in the number of choices based on the preferred attribute ($F = 5.64$, $df = 3, 28$, $p < .005$).

Table 3

Number Subjects at Each					
Grade Level Preferring			Number of Choices based		
Function, Form, or Color			on Preferred Attribute		
Grade	Attribute				
	Fu	Fo	C	Mean	S.D.
K	0	5	3	15.75	1.49
G1	2	5	1	16.50	3.21
G2	6	2	0	17.75	1.83
G3	7	1	0	18.00	1.51

No effects of sex were apparent, except that all three of the color-preferring Ss in K were girls. The single color-preferring S in G1 was a boy.

Experiment 2

The dependent measure for the analysis of the learning data was the number of correct responses made by a subject on each block of five trials. Figure 3 graphically presents the means for each of the relevant attributes separately for each grade level. The summary of the analysis of variance is presented in Table 4. Several components are further analyzed and the results are presented in Tables 5, 6, and 7. Since it was unlikely that the assumption of homogeneity of the variance-covariance matrices was met, a conservative test was performed (Geisser & Greenhouse, 1958).¹

The significant overall grade effect (G) merely reflects the fact that subjects in the higher grades made more correct responses. The overall difference among relevant attributes (A) falls just short of significance. However, a comparison of the Fu groups with the average of the Fo and C (perceptible attribute) groups (A_1 , Table 5) is significant. The Fu groups made significantly more correct responses than the Fo and C groups. There was no significant difference between the total correct of the Fo and C groups (A_2). None of the interactions between grade and relevant attribute were significant.

The significant effect due to trials (T) reflects an overall

¹A conservative test is performed by adjusting the degrees of freedom used to evaluate the significance of the obtained F ratios. This is accomplished by assigning one degree of freedom to all factors assigned within subjects and adjusting the degrees of freedom of the interactions involving these factors accordingly. The unadjusted degrees of freedom are used to compute the mean squares.

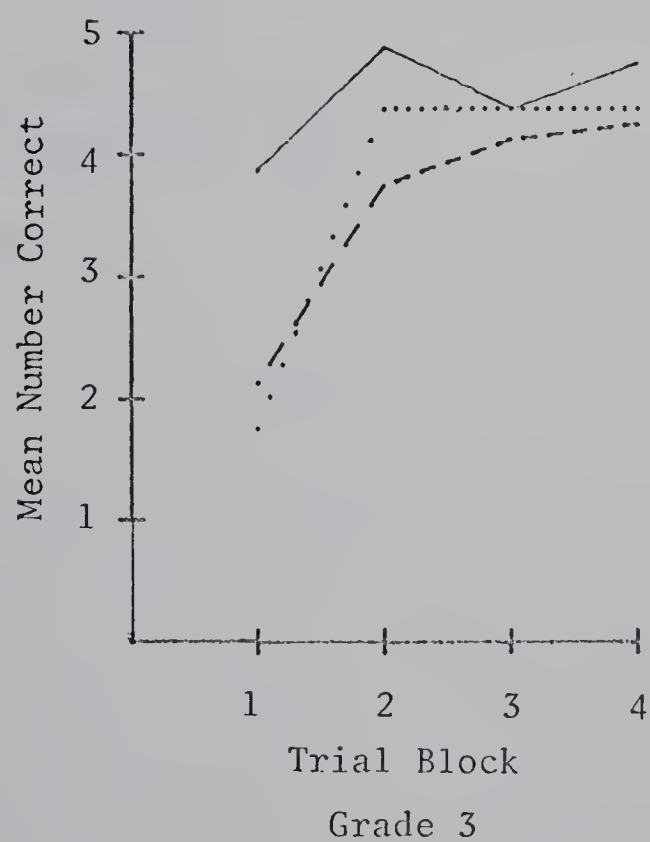
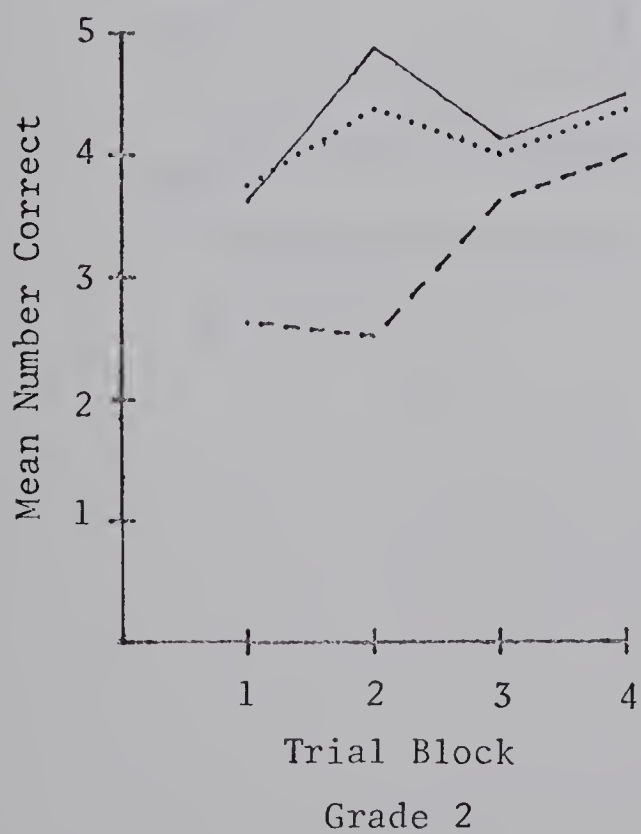
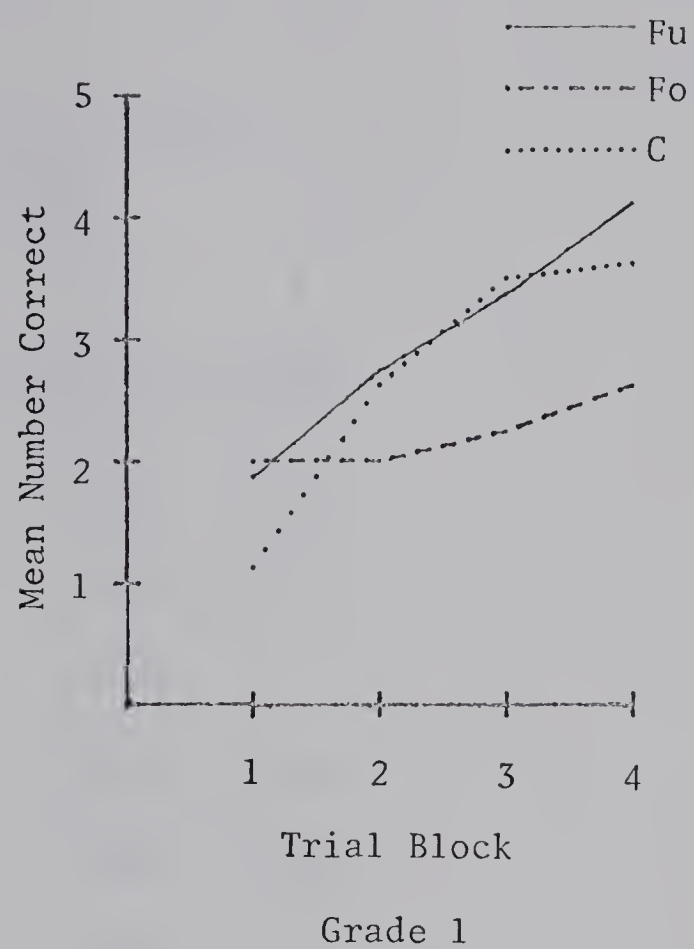
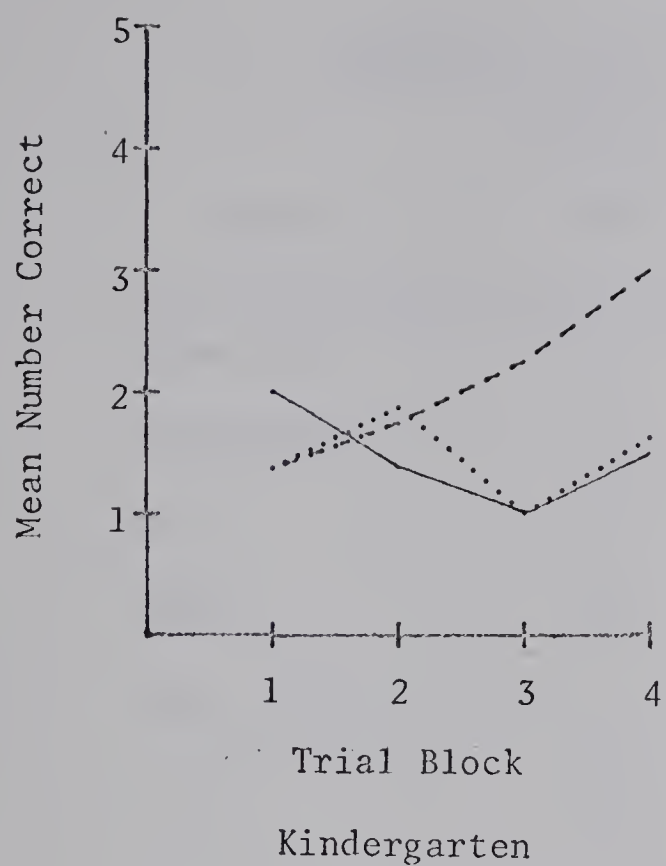


Figure 3. Graphs of the means for each attribute group and each grade level.

Table 4
Summary of the Analysis of Variance
of the Learning Data

Source	df	df (cons)	MS	F
Grade (G)	3		110.49	30.68*
Attribute (A)	2 ^a		9.61	2.67
G x A	6 ^a		6.21	1.73
S(G,A)	84		3.60	
Trials (T)	3	1	27.25	31.25*
G x T	9 ^b	3	3.92	4.49*
A x T	6 ^b	2	2.41	2.76
G x A x T	18 ^b	6	1.95	2.24
S(G,A) x T	252	84	.872	

^aFor further breakdown of these components, see Table 5.

^bFor further breakdown, see Table 6.

* $p < .01$.

Table 5

Orthogonal Components of the Attribute Main Effect
and Interaction with Grade

Source	df	MS	F
A_1 (Fu vs. Fo+C)	1	15.47	4.30*
A_2 (Fo vs. C)	1	3.75	1.04
G x A_1	3	5.44	1.51
G x A_2	3	6.98	1.94
S(G,A)	84	3.60	

* $p < .05$.

Table 6

Linear Components of the Interactions with Trials

Source	df	df (cons)	MS	F
G x T_{lin}	3		6.33	7.26**
A x T_{lin}	2 ^a		2.83	3.24*
G x A x T_{lin}	6 ^a		4.28	4.90**
S(G,A) x T	252	84	.872	

^aFor further breakdown, see Table 7.

* $p < .05$.

** $p < .01$.

Table 7

Orthogonal Components of the Interactions of Attribute
and the Linear Component of Trials

Source	df	df (cons)	MS	F
$A_1 \times T_{lin}$	1		5.48	6.28*
$A_2 \times T_{lin}$	1		.70	.80
$G \times A_1 \times T_{lin}$	3		2.97	3.40*
$G \times A_2 \times T_{lin}$	3		5.58	6.40**
$S(G,A) \times T$	252	84	.872	

* $\underline{p} < .05.$

** $\underline{p} < .01.$

increase in the number correct over blocks of trials. The $G \times T$ interaction is significant indicating that the trend over trials differs for different grade levels (see Figure 4). The significant linear component of this interaction (Table 6) reflects the differences in slope among the grade levels. The trends for K and G2 are relatively flat, with the K curve at a lower level than that for G2. The G1 and G3 trends both have relatively steep slopes, with the G1 curve beginning and ending at a lower point than the G3 curve.

The $A \times T_{lin}$ interaction (Figure 5) and its components $A_1 \times T_{lin}$ and $A_2 \times T_{lin}$ indicate that the slope for the Fu groups averaged over grades is less than the average slope for the Fo and C groups, mainly because the Fu curve starts at a higher point. There is no significant difference in slopes between the Fo and C groups when averaged over grades.

The significant linear component of the $G \times A \times T$ interaction was further broken down into $G \times A_1 \times T_{lin}$ and $G \times A_2 \times T_{lin}$, both of which were significant. The $G \times A_1 \times T_{lin}$ component indicates that the $A_1 \times T_{lin}$ interaction differs for different grade levels (see Figure 6). In G1, the slope for the Fu group exceeds that for the Fo and C groups combined. In K and G3, substantial differences in the other direction occur. In K, the means for the Fu group start low and decrease, while the averages of the Fo and C groups increase. In G3, the Fu means start and remain high while those of the Fo and C groups show an increase

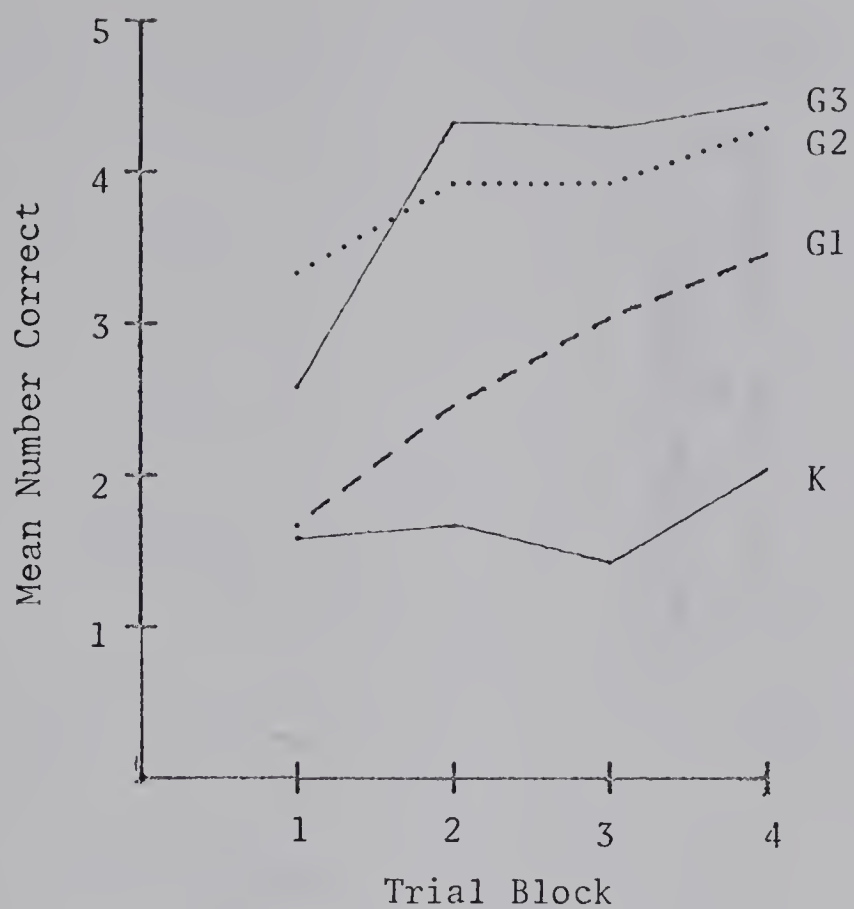


Figure 4. Graph of the G x T interaction.

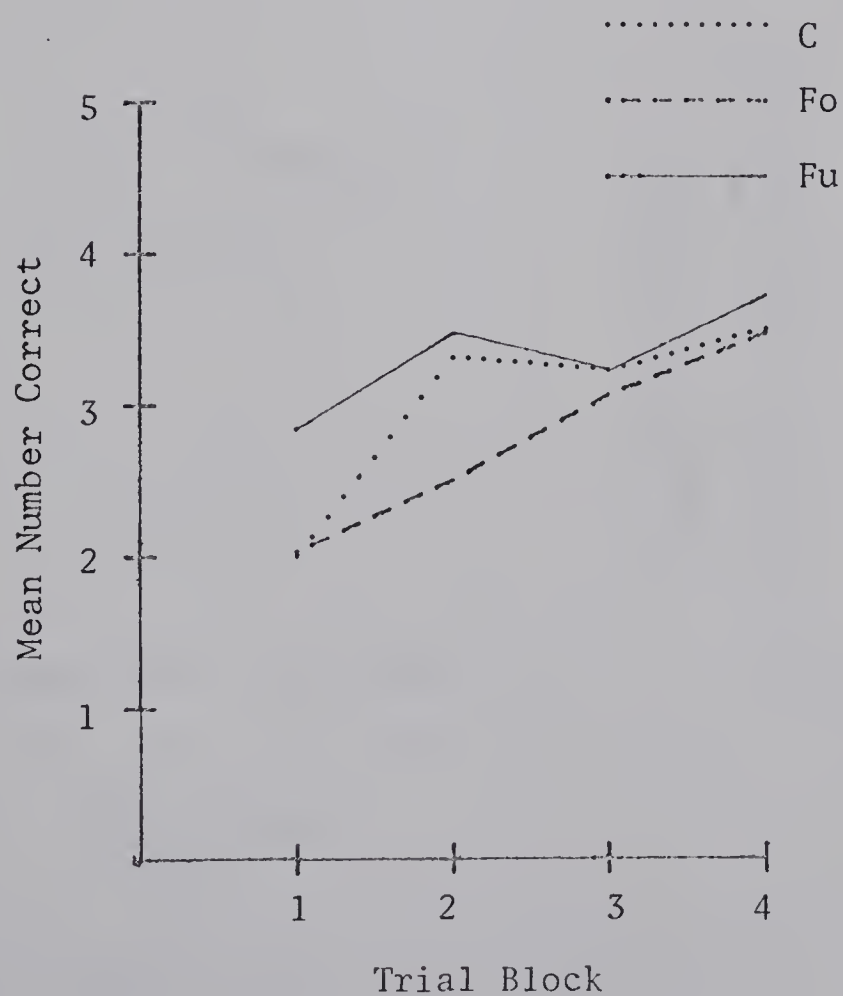


Figure 5. Graph of the A x T interaction.

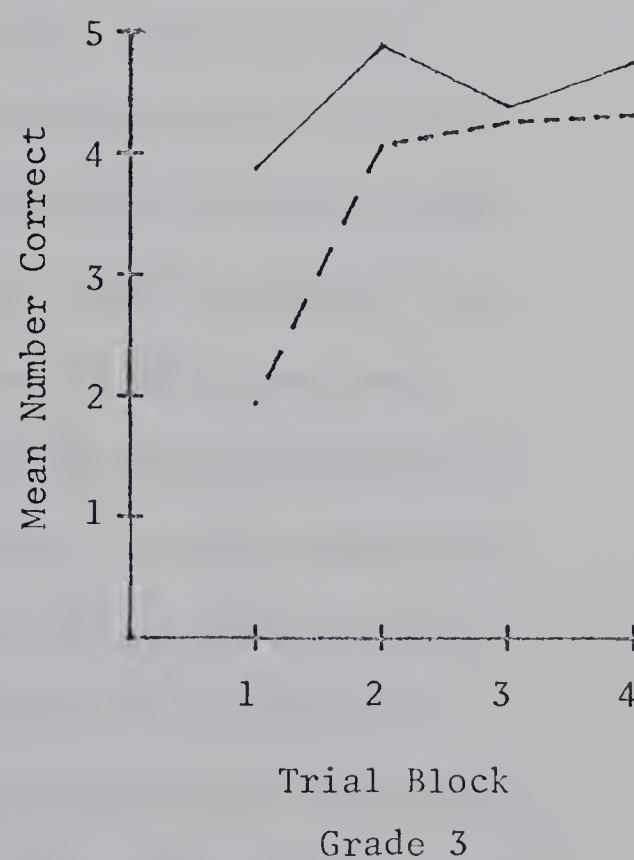
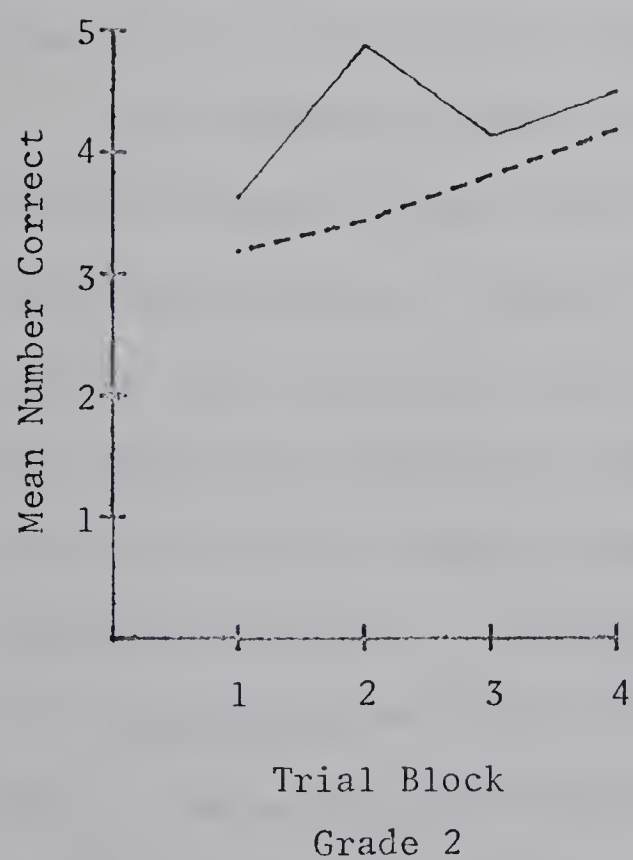
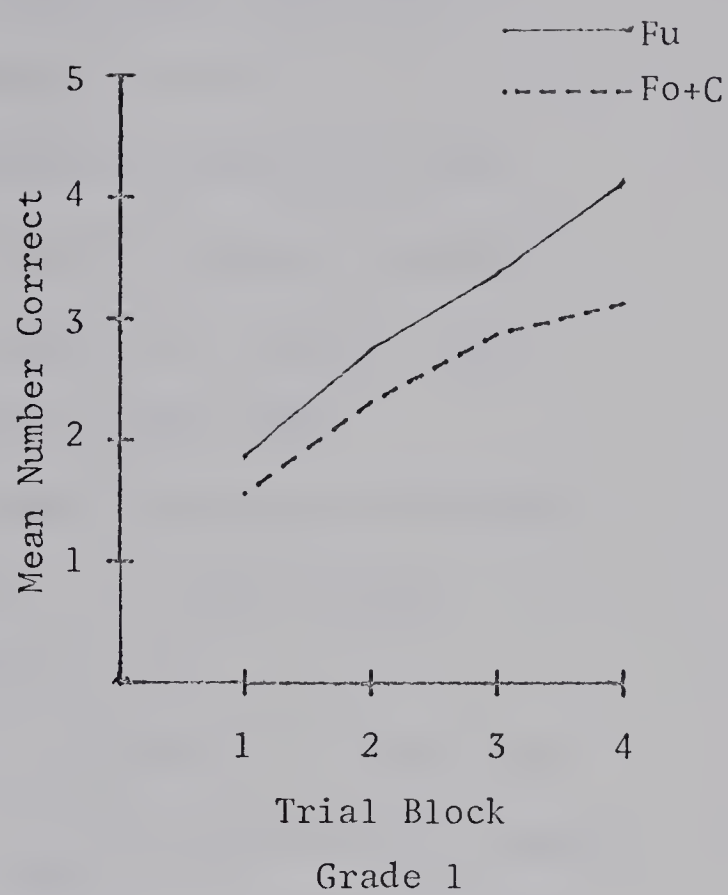
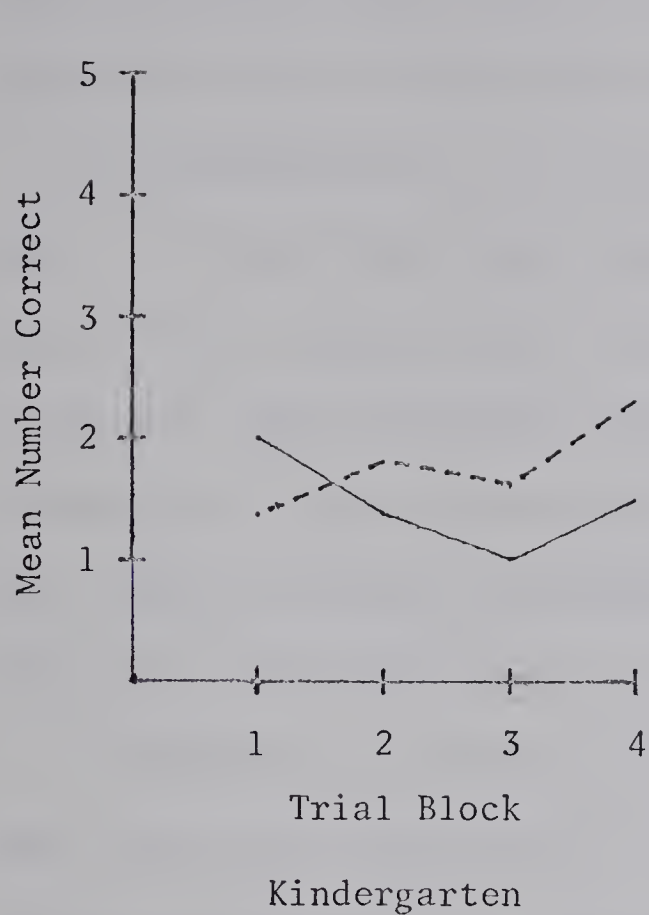


Figure 6. Graph of the $G \times A_1 \times T$ interaction.

from an initial chance level. G2 has a difference in the same direction, but it is less than the difference for G3.

The significant $G \times A_2 \times T_{lin}$ interaction reflects the fact that, in K and G2 the linear component in the Fo groups is greater than in the C groups, while in G1 the C group has a steeper slope. In G3, the slopes for the Fo and C groups are about equal. Although the K and G2 groups have differences in the same direction, they reflect different performance levels. In K, the C group starts and remains low while in G2 it starts high.

Interactions involving the quadratic components of trials were also tested for significance. The $A_2 \times T_{quad}$ and the $G \times T_{quad}$ interactions were significant. The three-way interactions were insignificant. There were no significant differences between sexes (as assessed by t tests) in the total number of correct responses.

Three randomized groups analyses of variance were performed to see if there were any differences in the types of errors made in different grades. Only the first error made by a subject on a given trial was counted for the purposes of these analyses. Each subject was assigned a score designating the proportion of errors of each type that he made. The means of these scores are presented in Table 8. Two subjects in the Fu groups and one in the C groups made no errors and hence could not be assigned a score. The analyses of variance on the proportion of errors which were Fo errors indicated that there was a significant difference among grades in the C groups ($\underline{F} = 7.79$, $\underline{df} = 3,27$, $\underline{p} < .005$) and

in the Fu groups ($F = 7.60$, $df = 3, 26$, $p < .005$). No difference among grades was found in the proportion of Fu errors in the Fo groups.

Table 8

Mean Proportion of Total Errors of Each Type

Grade	Type Error	Attribute Group					
		Fu		Fo		C	
		Fo	C	Fu	C	Fu	Fo
K		.48	.52	.65	.35	.45	.55
G1		.78	.22	.66	.34	.37	.63
G2		.91	.09	.70	.30	.74	.26
G3		.48	.52	.80	.20	.84	.16

The total number of trials on which a subject made two errors was the dependent variable for a 4 x 3 factorial analysis. The only significant difference was among grades, reflecting fewer double errors in the higher grades.

Only responses to the first three probe questions were scored. Each of the three responses was scored as indicating success or failure in verbalizing the appropriate criterion for the equivalence of that comparison stimulus with the standard stimulus. The subject was given credit if he mentioned either the attribute (color, form or shape, or function) or the specific value of the attribute (orange, round, to eat or fruit). The number of

subjects at each grade level who successfully verbalized 0, 1, 2, or 3 criteria is tabulated in Table 9. All the subjects from Experiments 1 and 2 were pooled for the purposes of this analysis. Data was missing for one of the K subjects of Experiment 1. A chi square analysis was significant ($\chi^2 = 31.807$, $df = 9$, $p < .01$).

Table 9

Number of Subjects at Each Grade Level
Verbalizing 0, 1, 2, or 3 Criterial Attributes

Grade	Number of Criteria			
	0	1	2	3
K	2	23	6	0
G1	2	23	4	3
G2	0	11	10	11
G3	0	11	9	12

Discussion

The results of Experiment 1 are in general agreement with previous findings concerning developmental changes in attribute preference. Choices of the comparison stimulus which was like the standard in color decreased with age, almost disappearing by G2. Choices based on form predominated in K and G1, and markedly decreased in frequency in G2. Choices based on function increased consistently over grades and formed a large majority of the choices of the G2 and G3 subjects. The same trend is evident whether we examine the total number of judgments based on each attribute, or the number of subjects exhibiting a preference for each attribute.

Before turning to the learning results, let us examine what is required for the adequate performance of the task. The subject must make equivalence judgments on the basis of the same criterial attribute for each stimulus set, though the value of the attribute varies from set to set. In other words, he must exhibit consistency in attribute usage from trial to trial. Further, if a non-preferred attribute is the relevant or defining attribute, the subject must exhibit flexibility if he is to alter the basis of his responding from the preferred to the defining attribute.

The available evidence suggests that both consistency and flexibility increase with age. Consistency is revealed in a tendency for an individual to use the same attribute as the basis for different equivalence groups. In Experiment 1, it was found

that the consistency with which individual subjects used their preferred attribute increased with grade level. This is in line with Colby and Robertson's (1942) finding that the percentage of subjects displaying pure dominance increased from 28% in their youngest group (3:5 - 4:5 years) to 85% in their oldest group (7 - 9:1 years). Inhelder and Piaget (1964) have also noted that such a trend occurs in their Stage II of classification and seriation, the stage of non-graphic collections. Early in Stage II, groupings are based on a multiplicity of criteria, for example, blue squares and circles may form one group (color) and red and yellow squares another (form) within the same sorting of a set of objects. Only later in Stage II do the fluctuations of criterion disappear. Several of the complexive structures described by Bruner et al (1966) involve fluctuations of criterion and are also more evident in younger children.

Flexibility is revealed in the ability of an individual to form two or more alternative groupings of a set of objects on the basis of different attributes. The evidence concerning flexibility in the present study is provided by verbal responses to the probe questions. At a verbal level, we find that a higher proportion of G2 and G3 subjects were able to immediately provide two or three criterial attributes which linked the comparison and the standard stimuli. The great majority of the K and G1 subjects could only verbalize one such attribute. Inhelder and Piaget (1964) have noted a similar trend when subjects are required to sort

stimuli which vary on three attributes, each with two values, into two groups. The percentage of children who are able to make two or three adequate sorts increases from 27% of the five year olds to 100% of the 8 - 9 year olds. Kofsky and Osler (1967) found a similar trend in 5 - 11 year olds on a card-sorting task.

In the learning situation, consistency is required once the relevant attribute is discovered if a high level of performance is to be attained. An increase over trials in the number correct (learning) would probably reflect a discovery of the defining attribute and hence would depend on flexibility.

With these considerations in mind, let us look at the learning data. The K subjects in all attribute groups perform at about the chance level in the first block of trials (according to t tests comparing obtained means to the mean expected by chance, t's = .88, 1.11, and .63, all non-significant). In later trial blocks, the form group shows evidence of learning, indicating that some limited degree of flexibility may occur in at least some subjects. (Actually, the trend is due mainly to the performance of three subjects.) However, this must be qualified since form choices predominated in the K subjects in Experiment 1. Perhaps the initial low level of the form group in Experiment 2 is due to the "game" atmosphere. Perhaps the subjects felt that a diversity of responses was expected or that the experimenter would try to trick them. Later they may have reverted to their preferred mode of responding. Certainly there is no evidence of flexibility in the color and

function groups. These subjects on the average responded at chance level throughout the experiment and their errors were approximately evenly divided (45% function errors in the color group, and 48% form errors in the function group). The lack of even the degree of consistency found in Experiment 1 may have resulted from an attempt by the subjects to vary their criterial attributes in order to discover the defining attribute, accompanied by an inability to formulate the nature of the attributes. In addition, repeated failure may have led to a lack of interest in the task. Difficulty was experienced in getting some of the K subjects to pay continued attention to the standard stimuli.

In G1 definite evidence of flexibility begins to appear. Both the function and color groups show a distinct upward trend after starting at the chance level (t 's = .40 and 1.13). Since form choices were predominant among the G1 subjects in Experiment 1, this is probably real evidence of learning. In both groups, the majority of errors which did occur were form errors (63% in the color group and 78% in the function group). It should be noted that, in spite of the evidence of flexibility provided by the learning data, most of the G1 subjects did not show evidence of flexibility in their verbal responses to the probe questions. Bruner et al (1966) have also reported the appearance of certain overt behaviors before appropriate verbal responses can be given in the same situations. Young Eskimo children, for example, although they make up the same sorts of groupings as white children

of the same age, are unable to verbalize the basis for the grouping. Another example stems from these authors' work on conservation. "Conservation-in-action" has been found to precede conservation as a verbal judgment.

The puzzling finding in the G1 results is the poor performance of the form group. Perhaps a sampling error was responsible. Four of the eight subjects chose the function stimulus on the first trial, a somewhat higher proportion than in the other G1 groups. However, three of the eight subjects in the color group also chose function on the first trial, though that group evidenced learning. Another possibility is that the G1 subjects are in a transitional phase between form and function. If this transition is being mediated by environmental pressure, it is possible that the imposition of external contingencies such as reinforcement leads to something akin to repression of form groupings.

In the G2 and G3 groups, all groups performed at a high level in the last block of trials. Relatively little interference from the preferred attribute occurred, presumably because these subjects have developed consistency in using an attribute and flexibility with respect to which attribute they use. As might be expected, the function groups in G2 and G3 both perform well above chance on the first block of trials (t 's = 5.22 and 5.01, $df = 7$, $p < .01$). In G2, the color and form groups also perform above chance in the first trial block (t 's = 2.96 and 3.73, $df = 7$, $p < .05$). In G3, on the other hand, the form and color groups begin at

the chance level (t 's = .89 and .23) but learn quickly after the first block of trials. Heidbreder's data indicated a similar order of attribute usage in adult subjects (Heidbreder, 1946b; Heidbreder et al, 1948). The differences found between G2 and G3 in this respect may indicate that it takes longer for the G3 subjects to overcome their preference for function. The G3 subjects have presumably been using function as the basis of their equivalence judgments for a longer time and so their function preference may interfere to a greater degree with the use of other attributes. The higher proportion of function errors in the G3 form and color groups as compared with the G2 groups (80% and 84% for G3 compared with 70% and 74% for G2) lends support to an interference interpretation.

One supplementary observation seems worth noting. A difference in the meaning and usage of the word "like" was apparent in children of different ages. The predominant usage in K and G1 was "looks like." This, of course, is consistent with their reliance on perceptible attributes. Being able to attach a common label to two objects is apparently not sufficient to have them perceived as being alike at this level. One girl in G1, when pressed as to whether a banana and an orange were alike in any way, finally said: "They're fruit, but that's not alike." Subjects in G2 and G3, however, tended to use the phrase "is like." It was also found that when a subject failed to give an appropriate response to the

"alike" question, the relevant attribute could often be elicited by asking if the stimuli were "the same" in any way. This worked more often for the form and color pairs than for the function pairs. Perhaps a technique which avoided the use of the word "like" in the instructions would give different results. Perhaps simply telling the child that the standard gave a clue as to where the toy was hidden would be a worthwhile variation on the instructions used in this study.

In summary, clear evidence of a trend from reliance on perceptible attributes to reliance on functional attributes was found. Parallelling this was an increase in the consistency with which an attribute was used, and in the ease with which more than one criterial attribute could be verbalized (flexibility). The older subjects who spontaneously used functional attributes also showed flexibility in the ease with which they switched to perceptible attributes when reliance on the latter was reinforced. Most of them were also able to verbalize at least two alternative bases of equivalence. The youngest subjects, who spontaneously used perceptible attributes, showed no evidence of being able to switch to the functional attributes as the basis of equivalence. The G1 subjects on the other hand, who also used perceptible attributes spontaneously, were able to switch to the functional. Most G1 subjects, however, still did not show evidence of flexibility in their verbal responses.

The results of this study suggest that in older children (G2 and G3) attribute preference tells us little about what

attributes the children are able to generate and use, and that, in fact, these children can readily switch to non-preferred attributes if it pays to do so. This conclusion was indicated by both their learning data and from their verbal responses. The results did not indicate, however, that the youngest children studied (K) could use non-preferred attributes under the conditions of this experiment. Incomplete flexibility was seen in the G1 subjects who were able to use non-preferred attributes but were unable to verbalize them.

B I B L I O G R A P H Y

References

- Brian, C. R. and Goodenough, F. L. The relative potency of color and form perception at various ages. J. exp. Psychol., 1929, 12, 197-213.
- Bruner, J. S., Goodnow, J. J., and Austin, G. A. A Study of Thinking. New York: Science Editions, 1956.
- Bruner, J. S., Olver, R. R., and Greenfield, P. M. Studies in Cognitive Growth. New York: Wiley, 1966.
- Colby, M. G. and Robertson, J. B. Genetic studies in abstraction. J. comp. Psychol., 1942, 33, 385-401.
- Corah, N. L. Color and form in children's perceptual behavior. Percept. Mot. Skills, 1964, 18, 313-316.
- Geisser, S., and Greenhouse, W. W. An extension of Box's results on the use of the F distribution in multivariate analysis. Annals of Mathematical Statistics, 1958, 29, 885-891.
- Heidbreder, E. The attainment of concepts: I. Terminology and methodology. J. general Psychol., 1946a, 35, 173-189.
- Heidbreder, E. The attainment of concepts: II. The problem. J. general Psychol., 1946b, 35, 191-223.
- Heidbreder, E., Bensley, M. L., and Ivy, M. The attainment of concepts: IV. Regularities and levels. J. Psychol., 1948, 25, 299-329.
- Inhelder, B., and Piaget, J. The Early Growth of Logic in the Child: Classification and Seriation. New York: Harper, 1964.
- Kagan, J. and Lemkin, J. Form, color, and size in children's conceptual behavior. Child Developm., 1961, 32, 25-28.
- Kofsky, E. and Osler, S. F. Free classification in children. Child Developm., 1967, 38, 927-937.
- Lee, L. C. Concept utilization in pre-school children. Child Developm., 1965, 36, 221-227.
- Olver, R. R. A developmental study of cognitive equivalence. Unpublished doctoral dissertation, Radcliffe College, 1961.
- Suchman, R. G. and Trabasso, T. Color and form preference. J. exp. child Psychol., 1966a, 3, 177-187.

Suchman, R. G. and Trabasso, T. Stimulus preference and cue function in young children's concept attainment. J. exp. child Psychol., 1966b, 3, 188-198.

A P P E N D I C E S

Appendix A

List of Stimulus Sets

Set Number	Standard	Function	Form	Color
1	Milk Carton	Can of beans	High rise	Mitt(red)
2	Book	Newspaper	Window	Bird(blue)
3	Skirt	Glove	Kettle	Butter(yellow)
4	Trailer House	House	Hedge	Dress(pink)
5	Knife	Scissors	Candle	Bus(gray)
6	Faucet	Hose	Chair	Pot(gray)
7	Guitar	Piano	Pop bottle	Table(brown)
8	Airplane	Train	Telephone pole	Spoon(gray)
9	Peach	Ice Cream Cone	Baseball	Dress(yellow)
10	Crayon	Paints	Nail	Strawberry(red)
11	Lamp	Candle	Spade(Shovel)	Tree(brown)
12	Car	Bicycle	Hat	Sock(green)
13	Bed	Crib	Door	Truck(blue)
14	Tie	Pants	Baseball bat	Grapes(purple)
15	Radio	Phonograph	Shoebox	Tree(green)
16	Cigarette	Pipe	Pencil	Cup(white)
17	Plate	Bowl	Record	Block (blue)
18	Shoe	Shirt	Punching doll	Telephone(black)
19	Stove	Barbecue	Chest of drawers	Letter(white)
20	Armchair	Bench	Dresser	Pool(blue)
Probe	Orange	Banana	Clock	Flower(orange)

Appendix B

Probe Questions

The three questions on which the flexibility data were based were:

1. Which one of these (comparison stimuli) is most like this one (standard)?
2. Is this (comparison) like this (standard) in any way?
3. Is this (third comparison) like this (standard) in any way?

If the S answered "No," or gave no answer to one of the questions, E went back to that comparison stimulus (or stimuli) and asked further questions usually of the following form:

Now, look at this again. Is this like this in any way?

Is there any way they are the same?

If the S continued to say "No," E sometimes directed S's attention to the relevant attribute, e.g. "What color is this?" In the case of the Fu pair, E usually asked S to name the objects and then asked: "Are a banana and an orange alike in any way?"

E ended the session with the reassurance that their first answer was quite correct, and depending on the answers to the follow-up questions, pointed out that there was more than one correct answer: "They're all like it in some way."

Appendix C

Orders of Presentation

Serial Posi- tion	Order No. 1				Serial Posi- tion	Order No. 2			
	Set No.	Position				Set No.	Position		
		L	C	R			L	C	R
1	4	Fo	Fu	C	1	2	C	Fo	Fu
2	12	Fo	C	Fu	2	9	Fu	Fo	C
3	8	Fu	C	Fo	3	18	Fo	Fu	C
4	2	C	Fo	Fu	4	15	Fo	Fu	C
5	5	Fo	Fu	C	5	5	Fo	Fu	C
6	7	Fo	C	Fu	6	7	C	Fu	Fo
7	6	Fu	C	Fo	7	12	C	Fo	Fu
8	9	C	Fu	Fo	8	6	Fu	Fo	C
9	1	Fo	C	Fu	9	4	Fu	Fo	C
10	16	Fu	Fo	C	10	17	C	Fu	Fo
11	11	Fu	C	Fo	11	14	Fo	C	Fu
12	18	Fo	Fu	C	12	1	Fo	Fu	C
13	15	C	Fo	Fu	13	3	Fu	C	Fo
14	19	Fu	Fo	C	14	20	C	Fo	Fu
15	14	C	Fu	Fo	15	11	Fu	C	Fo
16	20	C	Fu	Fo	16	10	Fo	C	Fu
17	17	Fu	Fo	C	17	19	C	Fu	Fo
18	3	Fu	C	Fo	18	8	Fu	C	Fo
19	13	Fo	Fu	C	19	16	Fo	C	Fu
20	10	C	Fo	Fu	20	13	Fu	C	Fo

Order No. 3

Serial Posi- tion	Set No.	Position		
		L	C	R
1	17	C	Fu	Fo
2	9	Fo	C	Fu
3	8	Fo	C	Fu
4	11	Fu	Fo	C
5	20	Fo	C	Fu
6	7	Fo	Fu	C
7	4	C	Fu	Fo
8	19	C	Fo	Fu
9	16	Fu	C	Fo
10	15	Fu	Fo	C
11	6	Fu	C	Fo
12	10	Fo	Fu	C
13	5	C	Fo	Fu
14	18	Fu	C	Fo
15	1	C	Fo	Fu
16	12	Fo	Fu	C
17	3	C	Fu	Fo
18	2	Fu	Fo	C
19	14	Fo	Fu	C
20	13	Fu	C	Fo

Order No. 4

Serial Posi- tion	Set No.	Position		
		L	C	R
1	1	Fo	Fu	C
2	12	Fu	C	Fo
3	11	C	Fo	Fu
4	6	Fo	Fu	C
5	3	Fu	Fo	C
6	14	Fu	C	Fo
7	10	C	Fu	Fo
8	7	C	Fo	Fu
9	16	C	Fu	Fo
10	13	Fo	Fu	C
11	2	Fo	C	Fu
12	9	Fo	C	Fu
13	15	C	Fo	Fu
14	20	Fu	C	Fo
15	19	C	Fu	Fo
16	17	Fo	Fu	C
17	8	Fu	C	Fo
18	18	Fo	C	Fu
19	5	Fu	Fo	C
20	4	Fu	Fo	C

Order No. 5

Serial Posi- tion	Set No.	Position		
		L	C	R
1	20	Fu	C	Fo
2	11	Fu	Fo	C
3	13	C	Fu	Fo
4	10	C	Fo	Fu
5	4	C	Fu	Fo
6	7	Fu	C	Fo
7	2	C	Fo	Fu
8	1	Fu	C	Fo
9	9	Fo	Fu	C
10	8	Fu	C	Fo
11	6	Fu	Fo	C
12	3	Fu	Fo	C
13	17	Fo	Fu	C
14	16	Fo	C	Fu
15	5	Fo	C	Fu
16	19	Fo	Fu	C
17	12	C	Fo	Fu
18	15	C	Fu	Fo
19	18	Fo	C	Fu
20	14	Fo	Fu	C

Order No. 6

Serial Posi- tion	Set No.	Position		
		L	C	R
1	16	Fu	C	Fo
2	13	C	Fu	Fo
3	3	Fo	Fu	C
4	15	Fo	C	Fu
5	4	Fu	C	Fo
6	2	C	Fo	Fu
7	12	Fu	Fo	C
8	10	C	Fu	Fo
9	18	C	Fo	Fu
10	6	Fo	C	Fu
11	1	Fu	C	Fo
12	11	Fo	C	Fu
13	17	C	Fo	Fu
14	9	Fu	C	Fo
15	19	Fo	Fu	C
16	5	C	Fu	Fo
17	8	Fo	Fu	C
18	14	Fu	Fo	C
19	7	Fo	Fu	C
20	20	Fu	Fo	C

Order No. 7

Serial Posi- tion	Set No.	Position		
		L	C	R
1	8	C	Fo	Fu
2	1	C	Fu	Fo
3	6	Fu	C	Fo
4	10	Fo	Fu	C
5	9	Fo	Fu	C
6	11	Fo	C	Fu
7	2	Fu	Fo	C
8	5	Fo	C	Fu
9	15	C	Fu	Fo
10	12	Fu	C	Fo
11	7	Fo	Fu	C
12	3	Fu	Fo	C
13	18	C	Fo	Fu
14	20	C	Fu	Fo
15	14	Fu	C	Fo
16	16	Fu	Fo	C
17	19	Fo	Fu	C
18	4	C	Fo	Fu
19	13	Fu	C	Fo
20	17	Fo	C	Fu

Order No. 8

Serial Posi- tion	Set No.	Postion		
		L	C	R
1	9	Fo	Fu	C
2	7	Fu	Fo	C
3	18	Fo	C	Fu
4	20	Fu	C	Fo
5	14	Fo	Fu	C
6	12	C	Fu	Fo
7	1	C	Fo	Fu
8	19	Fu	C	Fo
9	6	Fu	Fo	C
10	8	Fo	Fu	C
11	17	Fu	C	Fo
12	3	Fo	C	Fu
13	15	Fu	Fo	C
14	11	Fo	C	Fu
15	16	C	Fu	Fo
16	2	C	Fo	Fu
17	5	Fu	C	Fo
18	13	C	Fo	Fu
19	4	C	Fu	Fo
20	10	Fo	Fu	C

B29925